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RESEARCH PAPER

ASSESSMENT OF WATER QUALITY FOR HUMAN CONSUMPTION FROM SELECTED LAKES IN THE UPPER BENUE VALLEY OF ADAMAWA STATE, NORTHEASTERN NIGERIA

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ABSTRACT

Based on observations that some fluviatile lakes in the upper Benue Trough area of Adamawa state serve as sources of water for human consumption, this paper assesses the water quality of Lakes Gwakra, Ribadu and Parya. The studied lakes were purposively selected on the bases of observed facts that their waters are often used for drinking by residents of settlements in their vicinities. Water samples from the lakes were collected using standard field and Laboratory procedures. Laboratory results of the lakes' Physico-chemical and Toxic parameters were compared with recommended drinking standards provided by SON/WHO. Overall Water Quality Statuses of the lakes were determined using the Arithmetical Water Quality Index Method. Results showed that most of the lakes' Physico-chemical parameters are within permissible limits of drinking water standards provided by SON/WHO. However, overall Water Quality Indices of the lakes (153.36, 149.62 and 88.59 for Gwakra, Ribadu and Parya respectively) confirmed the lakesas unfit and very bad sources of safe drinking water for humans in the area. Analysis of Variance (ANOVA) with p-value of 0.864 at 95% CIs further revealed that there is no significant difference in the chemical content of the lakes owing to unvarying geologic characteristics and consistent landuse activities in the area. Therefore, qualitative treatment of the lakes' water is recommended before consumption.

KEYWORDS: Lakes, Upper Benue Valley, Physico-chemical parameters, Water Quality Index, Safe Drinking Water.

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INTRODUCTION

Considering the relevance of water to life on earth, one cannot single out discussions on its availability in terms of quantity without having a thought on its quality for whatever use. This is because the quality of water is equally important as its quantity (Khwakaram *et al.*, 2012) if not better. Even in areas of abundance, poor water quality can have direct impact on its quantity, in the sense that polluted water that cannot be used for drinking, bathing, industry or agriculture effectively can reduce the amount of useable water in a given geographical area (United Nations World Water Cooperation, 2013).

Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection (World Health Organization2006). This right and policy is hardly attainable today based on the facts that two million tons of sewage and other effluents are drained into the world waters every day; and that on yearly basis, more people die from unsafe water than from all forms of violence including war (United Nations World Water Cooperation, 2013). It also important to note that inaccessibility to safe drinking water is most prevalent in underdeveloped and developing countries owing to scarcity and poor quality. About 1.8 million people in the developing countries, mostly children, die from water related diseases every year (World Health Organization 2004). This is most likely because large sections of the people depend on raw water sources for drinking with poor or no treatment.

In Nigeria, the Federal Environmental Protection Agency (FEPA) in 1988, issued a specific decree that empowered the agency to set a water quality standard to protect public health and to enhance the quality of waters. Consequently, the Interim National Water Quality Guidelines and Standards for Nigeria was generated and subjected to temporal review by experts (Enderlein *et al*., 1997). Yet, problems of accessibility to safe drinking water still linger in many parts of the country, most especially the rural areas. Over 30% of the people of Adamawa State depend on water from streams and ponds/lakes for drinking and cooking (National Bureau of Statistics, 2010). The Upper Benue Valley Area of Adamawa State is endowed with many Fluviatile Lakes/ponds on which many people (mostly rural dwellers) depend on for livelihood. Residents around most of the Lakes/ponds depend greatly on them water for drinking, cooking and bathing water alongside other uses as Fishing, Irrigation farming and Recreation. Having examined the water quality statuses of some of the lakes for livestock (Cattle, Sheep and Goats) consumption in the area in the area (Yonnana *et al.*, 2014), this study aims at assessing the water quality of some of the lakes for human consumption.

The area within which the studied lakes are situated lies between latitudes 09˚ 09′ 00″N and 09˚ 33′ 00″N of the equator and between longitudes 12˚ 21′ 00″E and 12˚ 54′ 00″E of the Prime Meridian (Fig 1).

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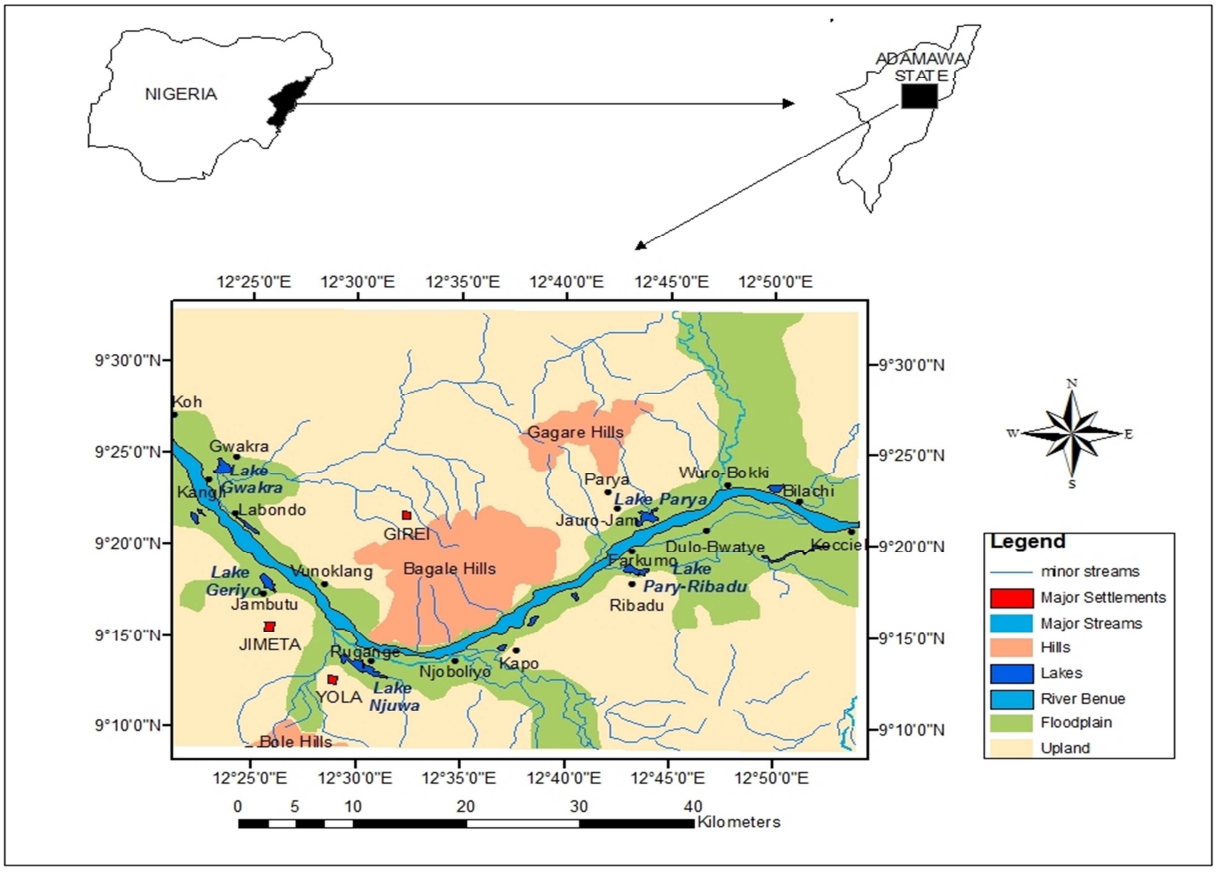

Figure1. Study Area

The area is geologically characterized by Albian Feldspathic and Calcareous sediments (Bima Sandstones) formed in the Cretaceous period (Kogbe, 1981; Bawden, 1972). Overlying the sandstones of the area are two major forms of Quaternary marine deposits – Benue valley alluvium and recent river alluvium (Bawden and Tuley 1966), within which the lake basins were formed. Major sources of water for the lakes include Run off from various land uses, floods from the River Benue and underground inputs. These Geologic, Fluvial and Human factors expose the lakes to varieties of Physico-chemical contaminants. This informs the need for temporal assessment of their water quality for human consumption.

MATERIALS AND METHODS

The study was carried out on water samples collected in dry (January, February and March) season 2013 owing to the fact that the lakes serve more as drinking water source in dry seasons

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when alternatives sources (rain and ground water) are scarce. The water samples were collected in clean one-liter bottles at 0.3m depth as described by Sisodia and Moundiotiya (2006) and Maitera*et al*.,(2011) and at three different points across each lake. The three samples collected from each lake were then poured into a container and a composite sample of one liter was drawn and treated with 10ml of HNO_3 to maintain the status of cations in solution and slow down biological changes before reaching the laboratory for physicochemical tests. The addition of 10ml of concentrated HNO_3 was in accordance to the recommendation made by Maitera *et al*.,(2011). Total Dissolved Solids (TDS), Turbidity, and Hardness of water samples were tested by Gravimetric, Colorimetric and Titrimetric methods respectively. Chemical concentrations (Na, K, Mg, Ca, Cl^-, SO_4^{2-}, CO_3^{2-}, PO_4^{3-}, NO_3^-) and Heavy Metals (Cd, Co, Cr, Ni, Pb, Zn) were tested by Atomic Absorption Spectrophotometric (AAS) method. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and fecal coli form count were examined by Oxygen meter, Winker's method and Eijkman tests respectively. Water pH, was tested directly on the field by Color Match Method (CMM).

Quality Index Analysis was used for ascertaining the lakes' water quality status for human consumption. Using the lake's Physico-chemical data generated, general Water Quality Statuses (WQS) of the lake for human consumption in dry season were ascertained using the Weighted Arithmetic Index Method of Water Quality Index (WQI) assessment as described by Brown *et al*.,(1972) and Chauhanand Singh(2010). The index is a single number that expresses overall quality of a water body at a time based on several water quality parameters with the objective of transforming complex data into understandable information for public use (Thakor *et al*.,2012). Fourteen (14) important water quality physico-chemical parameters of the lake and their corresponding standard values for drinking water quality as recommended by Standard Organization of Nigeria (SON) and World Health Organization (WHO) were used in calculating the Water Quality Index (WQI) for the lake.

In the calculation procedure, water quality rating (Q_n) for each parameter was calculated using the following formula:

$$\boldsymbol{Q_n = \frac{V_n - V_{io}}{V_s - V_{io}} * 100} \text{.....Equation 1}$$

Where;
Q_n= Water quality rating of each parameter
V_n= Observed value of water quality parameter obtained from laboratory analysis
V_{io}= Ideal value of water quality parameter as obtained from standard tables (i.e., zero (0) for all other parameters with the exception of pH and Dissolved Oxygen (DO) having 7.0 and 14.6mg/l respectively).

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V_s= Standard permissible value of water quality parameter as recommended by SON/WHO.

The relative weight for each water quality parameter was then calculated as a value inversely proportional to recommended standard value (Vs) of the parameter i.e.

$$Wn=\frac{K}{Vs} \quad \text{……Equation 2}$$

Where
Wn= Unit weight for water quality parameter
K= Constant of proportionality expressed as;

$$K=\frac{1}{\frac{1}{Vs1}+\frac{1}{Vs2}+\frac{1}{Vs3}+\cdots+\frac{1}{Vsn}} \quad \text{……..Equation 3}$$

The overall WQI was then calculated by aggregating the water quality rating with unit weight linearly, using the Weighted Arithmetic Index equation:

$$WQI=\frac{\sum Q_n W_n}{\sum W_n} \quad \text{……Equation 4}$$

Finally, the WQS of the lake was determined using Grads Water Quality Index and Status rating as presented by Khwakaram *et al.,* (2012) [Table 1].

Table1. Grads Water Quality Index and Status of water quality

Water Quality Index Levels	Water Quality Status Description
<50	Excellent Water
50 – 100	Good Water
100 – 200	Poor (Bad) Water
200 – 300	Very Poor (Bad) Water
>300	Unsuitable (unfit) for drinking

Adopted from Khwakaram *et al* (2012).

The effects of heavy metals and biological contaminants (Total coli form) on the lake water quality for human consumption were assessed by comparing observed values with drinking water standards values recommended by SON/WHO. Analysis of Variance (ANOVA) was used in determining whether there are variations in the chemical content of the lakes.

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RESULTS AND DISCUSSION

Mean concentrations of Physico-chemical and toxic parameters of the lakes are presented on Tables 1 and 2. The results showed that concentrations of the physico-chemical parameters range from low to moderate. Analysis of Variance (ANOVA) result (p-value=0.864 at 95% Confidence Interval) showed that there was no significant difference in the physico-chemical contents of the three lakes. This form homogeneity in the chemical statuses of the lakes is tied to uniformity in the underlying geologic structure and Fluvio-geomorphic setting of the area on which the lakes are situated as well as prevalence of common land use types (Farmlands and Residential) from which run offs flowing into the lakes are generated. Contents of Total Coli-form were very high (2,250CFU to 2,720CFU), owing to disposal of animal faeces within and around the lakes as well as effects of shallow depths, low Relative Depths and low Indices of Basin Performance (IBP) of the lakes, which enhance high biological productivity as described by Yonnana *et al.*, (2015).

Table 1: Mean Concentrations and Standard Deviation of the Lakes Physico-chemical Parameters and Recommended Standards for Drinking Water

Parameters	Unit	Lake Gwakra	Lake Ribadu	Lake Pariya	SON/WHO Standards
Na^{+}	mg/l	20.42±0.02	17.72±0.03	15.14±0.03	200.00
Mg^{2+}	mg/l	19.11±0.02	21.21±0.01	18.13±0.03	50.00
Ca^{2+}	mg/l	24.6±0.02	27.19±0.02	20.2±0.04	100.00
Cl^{-}	mg/l	9.12±0.09	9.15±0.02	7.87±0.07	250.00
SO_4^{2-}	mg/l	8.01±0.01	2.18±0.02	2.7±0.02	100.00
$PO4^{3-}$	mg/l	0.24±0.02	0.16±0.00	0.20±0.01	0.40
NO_3^{-}	mg/l	5.5±0.01	5.10±0.02	8.19±0.03	50.00
DO	mg/l	5.13±0.12	5.73±0.06	6.27±0.06	5.00
BOD	mg/l	3.73±0.06	3.67±0.06	3.67±0.12	6.00
TDS	mg/l	85.33±0.50	95.00±0.00	92.00±0.00	500.00
pH		7.83±0.06	7.10±0.17	8.10±0.10	6.5-8.5
Hardness	mg/l	43.71±0.02	48.39±0.03	38.33±0.04	150.00
Turbidity	TNU	85.00±0.00	94.00±0.00	38.00±0.00	5.00

Table 2: Toxic and Bacterial properties of Lake Parya-Ribadu in Dry season, 2013

Lakes	Mn (mg/l)	Cd (mg/l)	Ni (mg/l)	Zn (mg/l)	Pb (mg/l)	Total Coli-form (CFU)
Gwakra	0.07±0.01	0.04±0.00	0.03±0.00	0.12±0.01	0.02±0.00	2,250
Ribadu	0.26±0.01	ND	ND	0.13±0.01	0.02±0.00	2,650
Parya	0.17±0.00	ND	ND	0.11±0.00	0.02±0.00	2,720
WHO/SON Standards	0.05	0.01	0.02	3.00	0.01	10

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Comparing the Physico-chemical, toxic and bacterial contents of the lakes with recommended standards for drinking water provided by Standard Organization of Nigeria (SON) and World Health Organization (WHO), it was observed that almost all contents of the respective parameters were within the permissible limits of drinking water with the exception of Dissolved Oxygen contents (5.13mg/l, 5.73mg/l and 6.27mg/l for Lakes Gwakra, Ribadu and Parya respectively) and Turbidity values for all the lakes. However, considering the combined effects of the parameters based on Water Quality Index (WQI) analysis, the lakes were found to be unfit for human (Table 3).

Heavy metals and Total Coli-form contents of the lakes were beyond permissible limits with the exception of Zinc (Zn). This indicates toxicity and existence of harmful bacteria which can cause gastrointestinal diseases such as *Giardiasis* and *Cryptosporidiosis* as well as Urinary infections alike.

CONCLUSION

Despite the fact that the fluviatile lakes in the Upper Benue Valley of Adamawa State serve as vital life sustaining water bodies, the current study revealed the lakes are in very poor water quality statuses for human consumption. Residents around the lakes, who use them as sources for drinking water are exposed to various forms of water borne diseases and infections. Thus the aim and objectives the Federal Environmental Protection Agency (FEPA) established in 1988 are defeated. Therefore, it is strongly recommended that water extracted from the lakes for human consumption should be treated properly before usage. Besides, temporal assessment of water a quality status of the lakes is also recommended for sustainable use.

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Table 3: Water Quality Indices and Statuses of the Studied Lakes

S/No				Actual measured values (Vn)			
	Parameters	Units	Maximum Standard Permitted Level (Sn)	Lake Gwakra	Lake Geriyo	Lake Ribadu	Lake Pariya
1	Na	mg/l	200.00*	20.42	23.69	17.72	15.14
2	Mg	mg/l	50.00**	19.11	23.12	21.21	18.13
3	Ca	mg/l	100.00**	24.60	26.14	27.19	20.20
4	Cl^-	mg/l	250.00*	9.12	10.48	9.15	7.87
5	$SO4^{2-}$	mg/l	100.00*	8.01	6.07	2.18	2.70
6	$PO4^{3-}$	mg/l	0.40**	0.24	0.26	0.16	0.20
7	$NO3^-$	mg/l	50.00*	5.50	7.23	5.10	8.19
8	DO	mg/l	5.00**	5.13	4.77	5.73	6.27
9	BOD	mg/l	6.00**	3.73	3.30	3.67	3.67
10	TDS	mg/l	500.00*	85.33	87.00	95.00	92.00
11	pH		8.50*	7.83	8.57	7.10	8.10
12	TH	mg/l	150.00*	43.71	49.26	48.39	38.33
13	Turbidity	NTU	5.00**	85.00	102.00	94.00	38.00
	WQI	…….	…….	153.96	178.38	149.62	88.59
	WQS	…….	…….	Unfit for drinking	Unfit for drinking	Unfit for drinking	Very bad water

*Standard Organization of Nigeria (SON); **World Health Organization (WHO)

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